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PENAEID SHRIMP CULTURE RESEARCH AT THE
NATIONAL MARINE SERVICE GALVESTON LABORATORY

Abstract

Recent research activities of the National Marine Fisheries Service Galveston Laboratory of the Gulf Coastal Fisheries Center directed toward the development of the background biological information on penaeid shrimp required by shrimp culturists are reviewed. Four general areas of research in penaeid biology and culture are described: maturation and spawning; nutrition and feeds; disease diagnosis and control; and intensive culture in controlled environments. Significant publications and progress resulting from this research are noted and the information in these publications is summarized. Present activities and planned areas of emphasis in the Laboratory's research projects include: experimentation to refine the method of in vitro fertilization of captive shrimp, further tests with diets to evaluate components, such as fatty acids, determining means of controlling and preventing shrimp diseases, and applying environment control systems developed at Galveston Laboratory to shrimp culture techniques.

RECHERCHE SUR LA CULTURE DES CREVETTES PENEIDES AU LABORATOIRE DU
NATIONAL MARINE SERVICE A GALVESTON

Résumé

On examine les récentes activités de recherche menées au Laboratoire du National Marine Fisheries Service du Gulf Coastal Fisheries Center à Galveston en vue d'élaborer les informations biologiques de base sur la crevette pénéide nécessaire aux éleveurs de crevettes. Quatre domaines généraux de recherche sur la biologie et la culture des pénéides sont décrits: maturation et frai; nutrition et aliments; diagnostic et lutte contre les maladies; culture intensive en milieu contrôlé. Les publications importantes et les progrès découlant de ces recherches sont indiquées, et les renseignements figurant dans ces publications sont résumés. Les activités présentes et les orientations futures des travaux de recherche du laboratoire sont les suivantes: expérimentation pour perfectionner la méthode de fertilisation in vitro des crevettes captives; poursuite des essais sur l'alimentation pour en évaluer les éléments tels que les acides gras, détermination des moyens de prévenir les maladies des crevettes et du lutter contre elles, et d'appliquer aux techniques de culture des crevettes les systèmes de contrôle de l'environnement mis au point au Laboratoire de Galveston.

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INVESTIGACIONES SOBRE CULTIVO DE CAMARONES PENEIDOS EN EL LABORATORIO
DE GALVESTON DEL SERVICIO NACIONAL DE PESCA MARITIMA

Extracto

En este trabajo se examinan las investigaciones realizadas recientemente en el Laboratorio de Galveston (Centro para las Pesquerías Costeras del Golfo, Servicio Nacional de Pesca Marítima) para reunir la información biológica básica sobre los camarones peneidos que necesitan quienes se dedican a su cultivo. Se describen cuatro sectores en los que se han realizado investigaciones en relación con la biología y el cultivo de peneidos: maduración y desove; nutrición y piensos; diagnóstico de enfermedades y lucha contra ellas; y cultivo intensivo en ambientes controlados. Se reseñan las publicaciones y progresos más importantes derivados de esas investigaciones y se resume brevemente la información contenida en las publicaciones mencionadas. Entre las actividades actuales y futuras de los proyectos de investigación en laboratorio figuran: experimentos para mejorar el método de fertilización in vitro de camarones cautivos; nuevos ensayos con raciones alimenticias para evaluar algunos componentes, como los ácidos grasos; preparación de medios para luchar contra las enfermedades de camarones y prevenialas; y aplicación al cultivo de camarones de sistemas de control del medio preparados por el Laboratorio de Galveston.

1. INTRODUCTION

Research on the biology and culture of penaeid shrimp has been conducted at the Galveston Laboratory of the National Marine Fisheries Service Gulf Coastal Fisheries Center for a number of years. That portion of the activity oriented toward the culture of penaeid shrimp has been reviewed by Lindner and Cook (1971), Neal (1973), Neal (1974) and Neal (in press). Only recent research activities and progress at the Laboratory will be discussed including the solution of basic problems in four general areas of penaeid shrimp biology and culture.

2. MATURATION AND SPAWNING

Earlier research concerning inducement of penaeid maturation and spawning in captivity was directed along two lines: experimental manipulation of environmental conditions and the formulation of suitable diets for maturing penaeids. Neither of these approaches resulted in a definitive solution. Partial ovarian development in some experimental animals led to the assumption that the factors: light intensity, light wave length, pH and some unknown chemical aspects of water quality, influenced maturation. While other unidentified environmental parameters may also affect development, no clear relationships between dietary components and maturation were established.

Because of the complexity of the problem of determining the role of water chemistry in maturation, and because of the need for a simple technique for maturing females in captivity, a new approach to the problem was initiated. This approach consisted of a thorough description of the normal reproductive processes at the light and electron microscopy levels, and experimental manipulation of the endocrine system of shrimp evaluated by comparison with the normal situation.

Much of the descriptive work on normal penaeid reproductive development has been done in cooperation with scientists from the University of Houston. The male reproductive system has been described by Lu and Clark (1975). Ovarian development is discussed by Duronslet et al. (in press) and the cortical reaction is described by Clark, Lynn and Persyn (1975) and by Clark, Persyn and Yudin (1974).

This understanding of the normal reproductive process at the cellular and fine structural levels provides a basis for the comparison of normal and experimental animals. Using this tool, experimental manipulation of the endocrine systems has been initiated in conjunction with a thorough description of the effects of each technique tested.

The effects of the manipulation techniques, such as eyestalk ablation, apparently vary depending upon both the species and the environmental conditions. Although our understanding of these interactions is incomplete, the results of work in Galveston with brown shrimp, Penaeus aztecus, have been described by Duronslet et al. (in press). Ovarian development can be induced routinely by eyestalk ablation, and spawning has been induced in a few ablated shrimp; spawning of these shrimp is still, however, apparently a major problem. Diener, Yudin and Clark (1975) have identified the ecdysial gland of the blue crab, Callinectes sapidus. Transplants of this gland and its extracts have pronounced effects on shrimp moulting, but the effect on gonadal development is not clear. The effects of injections of various insect and mammalian hormones are also poorly understood even though experimentation with these hormones is underway.

A tool which has many applications in breeding studies, as well as in the spawning of captive shrimp on demand is in vitro fertilization. A method for in vitro fertilization has been described by Clark et al. (1973) and experiments to refine the method are in progress.

3. NUTRITION AND FEEDS

The development of diets for penaeid shrimp has followed two separate paths: (i) the formulation of diets for rearing shrimp in semi-natural ponds where natural foods are available; and (ii) the formulation of diets for use in tanks where little or no natural food is available.

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The objective of research on nutrition and feeds has been to develop suitable diets for use in tanks where water is being circulated. Research workers at the Galveston Laboratory established that a worm-shaped extruded pellet was an acceptable form for juvenile and adult penaeid shrimp (Meyers and Zein-Eldin, 1972) and that a drum-dried flake was a suitable form for postlarval penaeids (Meyers and Brand, 1975; Mock, Neal and Salser, 1973). The most satisfactory binder found for experimental diets used in nutritional studies was an alginate (Meyers and Zein-Eldin, 1972). In addition, the attractant chosen for experimental research was fish solubles (Zein-Eldin and Meyers, 1973).

As the result of a long series of diet comparisons, a standard experimental diet was established for use in experimental studies. This diet (5-5/70B) will produce good growth of Penaeus aztecus and P. setiferus under experimental conditions and is designed to permit substitution of individual ingredients without gross modification of its nutritional characteristics (Zein-Eldin and Meyers, 1973). This diet has been used successfully in a number of high-density rearing experiments in closed raceway systems (Mock, Ross and Salser, MS).

Experimentation over several years has led to the conclusion that the diets used at Galveston Laboratory generally have a suitable amino-acid balance and that the 35-40 percent protein level is satisfactory within the constraints of the diet series tested (Fenucci and Zein-Eldin, in preparation). At this point other dietary factors seem to be limiting shrimp growth. Future experimentation with these diets will be planned, therefore, to evaluate other dietary components, such as fatty acids.

4. DISEASE DIAGNOSIS AND CONTROL

The objective of the shrimp disease research programme of the National Marine Fisheries Service in Galveston is to conduct studies necessary to identify, treat and prevent diseases in penaeids under culture conditions. The research activities have fallen into three broad categories: (i) the description of normal tissues and normal responses to injury or foreign materials; (ii) the description of shrimp pathogens and studies of their effects on shrimp; and (iii) studies of methods of preventing and treating diseases.

The normal tissues of several organs of shrimp as well as normal post-mortem changes were described by Lightner (1974). Wound repair processes of shrimp and crayfish (Procambarus) were discussed by Fontaine (1971), Fontaine and Dyjak (1973), Fontaine and Lightner (1973), and Fontaine (1975). The responses of penaeids to the introduction of foreign material was documented by Fontaine and Lightner (1974), Fontaine et al. (1975), Sparks and Fontaine (1973), and by Fontaine and Lightner (1975).

Specific diseases which have been described are: a gas-bubble disease in Penaeus aztecus (Lightner, Salser and Wheeler, 1974); a mycosis of the American lobster, Homarus americanus (Lightner and Fontaine, 1975); and a fungal disease of Penaeus setiferus larvae (Lightner and Fontaine, 1973). In addition, a discussion of gill diseases in penaeids has been prepared by Lightner, Fontaine and Hanks (in press), and a review of shrimp disease information published on U.S. species has been prepared by Lightner (in press).

Experimentation on means of preventing and controlling shrimp diseases has just begun. Diseases of captive shrimp frequently occur in association with a known environmental condition that causes stress. The experience at Galveston Laboratory has been that in such situations the removal of the stress-inducing factor usually stops the spread of the disease. As a preliminary step to the treatment of diseases with antibiotics, the effects of oral doses of two antibiotics, oxytetracycline and furozolidone, on normal shrimp was studied (McGaffey, Lightner and Zein-Eldin, MS; McGaffey and Zein-Eldin, MS).

5. INTENSIVE CULTURE IN CONTROLLED ENVIRONMENTS

The goals of this research have been to develop dependable methods for rearing shrimp at high densities, under controlled conditions, on a year-round basis. As winter temperatures in Texas ponds are lethal to penaeid shrimp, considerable research on temperature control has been conducted to find economical means of providing optimum temperatures for continuous growth. This temperature control work has led to recycling of water and consequently to the development of systems for water treatment and re-use.

The first phase of this research, that of improving hatchery techniques, has been completed. The methods developed permit the routine production of uniformly healthy, vigorous post larvae in about 10 days from hatching with survival rates exceeding 80 percent from hatching. These methods, which are used by several industrial groups, are discussed in papers by Mock and Murphy (1971), Mock and Neal (1974), Salser and Mock (in press), and Mock (1974).

The second phase has been the development of larger closed systems for rearing post-larval and juvenile penaeids to an intermediate size (30-60 mm) for subsequent restocking in larger pond or raceway systems. Research on these techniques is also nearing completion. Methods described by Mock, Neal and Salser (1973) and by Mock, Ross and Salser (MS) have proved to be efficient and dependable methods of rearing small shrimp at high densities with good survival. During these experiments post larvae have been reared at densities of 2 300/m² (22 mm), 12 500/m² (12 mm) and 26 100/m² (16 mm) with survival rates of 90-95 percent. Juveniles have been reared at densities of 100/m² (88 mm) to 1 600/m² (31 mm) with survival rates ranging from 80 to 97 percent.

During the second phase as well as the third phase in the production of marketable-size shrimp in closed raceway systems, the limiting factor has been the accumulation of wastes in the systems. In efforts to increase production per unit area in these systems a variety of water treatment methods have been tested. Treatment techniques tested were those which: permitted easy recovery of solid wastes or biological growths, required relatively small capital outlay and low operating expenses, and could be automated readily. Techniques which have been or are being tested are discussed by Mock, Neal and Salser (1973), Mock, Ross and Salser (MS) and Neal and Mock (1976). Waste treatment methods used in the system at present are: water aeration, particulate removal with inclined plate separators, and dissolved waste removal with biodisk filters and foam fractionation columns.

The design and construction of inexpensive tanks which permit a high level of environmental control has been the subject of detailed experimentation and developmental research. A simple portable raceway system consisting of walls constructed with fibreglass panels lined with styrofoam and supported by aluminium braces has been constructed. The system is lined with polyethylene and covered with a low-profile plastic cover. A floating centre wall is used to support the airlift pumps and one end of the raceway extends into a larger building where waste removal apparatus is housed (Mock and Neal, MS).

In summary, the research on methods of controlling environmental conditions to increase production in raceways has resulted in the development of a number of new techniques which have practical applications in both raceway and pond culture of marine organisms. Practical applications of environmental control are seen in intensive, closed systems (for shrimp larvae and post larvae) and in less intensive systems for larger shrimp and other marine organisms. The recycling of aquacultural wastes is a topic deserving considerable attention and research.

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6. REFERENCES

- Clark, W.H., Jr., J.W. Lynn and H. Persyn, The cortical reaction in the egg of the penaeid shrimp. Invertebrate reproduction. Paper presented to the International Symposium on Reproductive Physiology of Invertebrates, Calicut University, 10-12 September 1975 (Abstract)
1975
- Clark, W.H., Jr., H. Persyn and A.I. Yudin, A microscopic analysis of the cortical specializations and their activation in the egg of the prawn, Penaeus sp. Am.Zool., 14(4):25 (Abstract)
1974
- Clark, W.H., Jr. et al., In vitro fertilization with non-motile spermatozoa of brown shrimp, Penaeus aztecus. Mar.Biol., 22:353-4
1973
- Diener, R.A., A.I. Yudin and W.H. Clark, Jr., The ecdysial gland of the blue crab, Callinectes sapidus Rathbun. Am.Zool., 15(3):786 (Abstract)
1975
- Duronslet, M.J. et al., Light and fine structure studies of natural and artificially induced egg growth of penaeid shrimp. Paper presented at the Sixth Annual Workshop World Mariculture Society, January 1975
1975
- Fenucci, J.L. and Z.P. Zein-Eldin, Evaluation of squid mantle meal as a protein source in penaeid nutrition. Paper presented at the FAO Technical Conference on Aquaculture, Kyoto, Japan, 26 May-2 June 1976
1976
- Fontaine, C.T., Exoskeletal intrusions: a wound repair process in penaeid shrimp. J.Invert.Pathol., 18(2):301-3
1971
- _____, Observations on the wound repair processes in the freshwater crayfish, Procambarus sp. J.Invert.Pathol., 25(3):391-3
1975
- Fontaine, C.T. and R.C. Dyjak, The development of scar tissue in the brown shrimp, Penaeus aztecus, after wounding with a Petersen disk tag. J.Invert.Pathol., 22(3):476-7
1973
- Fontaine, C.T. and D.V. Lightner, Observations on the process of wound repair in penaeid shrimp. J.Invert.Pathol., 22(1):23-33
1973
- _____, Observations on the phagocytosis and elimination of carmine particles injected into the abdominal musculature of the white shrimp, Penaeus setiferus. J.Invert.Pathol., 24(2):141-8
1974
- _____, Cellular response to injury in penaeid shrimp. Mar.Fish.Rev., 37(5-6):4-10
1975
- Fontaine, C.T. et al., Histopathological response to turpentine in the white shrimp, Penaeus setiferus. J.Invert.Pathol., 25(3):321-30
1975
- Lightner, D.V., Normal postmortem changes in the brown shrimp, Penaeus aztecus. Fish.Bull., 72(1):223-36
1974
- _____, Some potentially serious disease problems in the culture of penaeid shrimp in North America. Paper presented to the UJNR Symposium on Disease of Marine Fishes, Japan (in press)
- Lightner, D.V. and C.T. Fontaine, A new fungus disease of the white shrimp, Penaeus setiferus. J.Invert.Pathol., 22(1):94-9
1973
- _____, A mycosis of the American lobster, Homarus americanus, caused by Fusarium sp. J.Invert.Pathol., 25(2):239-45
1975

- Lightner, D.V., C.T. Fontaine and K. Hanks, Some forms of gill disease in penaeid shrimp.
1975 Paper presented at the Sixth Annual Workshop of the World Mariculture Society,
January 1975
- Lightner, D.V., B.R. Salser and R.S. Wheeler, Gas-bubble disease in the brown shrimp
1974 (Penaeus aztecus). Aquaculture, 4:81-4
- Lindner, M.J. and H.L. Cook, Progress in shrimp mariculture in the United States. FAO Fish.
1971 Rep., (71)vol.2:157-62
- Lu, C.C. and W.H. Clark, Jr., A microscopic analysis of the male reproductive tract of
1975 Penaeus aztecus. Paper presented at the First Workshop on Pathology and Toxicology
of Penaeids, Galveston, Texas, 8-10 April 1975
- McGaffey, J.C., D.V. Lightner and Z.P. Zein-Eldin, The effects of oral doses of oxytetracy-
1975 cline on growth, survival and disease in Penaeus aztecus. Paper presented at
the Sixth Annual Workshop of the World Mariculture Society, January 1975 (MS)
- McGaffey, J.C. and Z.P. Zein-Eldin, The effect of oxytetracycline and furozolidone on
1975 growth, survival and disease in two species of penaeids. Paper presented at
the First Workshop on Pathology and Toxicology of Penaeids, Galveston, Texas,
8-10 April 1975 (MS)
- Meyers, S.P. and C.W. Brand, Experimental flake diets for fish and crustacea. Progr.Fish-
1975 Cult., 37(2):67-72
- Meyers, S.P. and Z.P. Zein-Eldin, Binders and pellet stability in development of crustacean
1972 diets. Proc.Annu.Workshop World Maricult.Soc., 3:351-64
- Mock, C.R., Larval culture of penaeid shrimp at the Galveston Biological Laboratory. NOAA
1974 Tech.Rep.NMFS Circ., (388):33-40
- Mock, C.R. and M.A. Murphy, Techniques for raising penaeid shrimp. Proc.Annu.Workshop
1971 World Maricult.Soc., 1:143-56
- Mock, C.R. and R.A. Neal, Penaeid shrimp hatchery systems. Paper presented to the FAO/
1974 CARPAS Symposium on Aquaculture in Latin America, Montevideo, Uruguay
- _____, Engineering aspects of a closed system for aquaculture. Paper presented at
1975 the Tenth European Symposium on Marine Biology, Ostend, Belgium, 17-23 September
1975 (MS)
- Mock, C.R., R.A. Neal and B.R. Salser, A closed system raceway for the culture of shrimp.
1973 Proc.Annu.Workshop World Maricult.Soc., 4:247-59
- Mock C.R., L.A. Ross and B.R. Salser, Design and evaluation of waste removal systems for
1975 shrimp culture in closed raceways. Paper presented at the Sixth Annual Workshop
of the World Mariculture Society, January 1975
- Neal, R.A., Progress toward farming shrimp. Mar.Fish.Rev., 35(3-4):67-70
1973
- _____, Shrimp culture in the United States. In Proceedings National Prawn Seminar,
1973a Maroochydore, Queensland, Australia, November 1973
- _____, Raceway systems for the culture of shrimp. Fish Farming Int., 3:6-11
1974

FIR:AQ/Conf/76/E.23

Neal, R.A. and C.R. Mock, A model closed system for aquaculture incorporating the recycling
1976 of wastes. Paper presented to the FAO Technical Conference on Aquaculture,
Kyoto, Japan, 26 May-2 June 1976

Salser, B.R. and C.R. Mock, Equipment used for the culture of larval penaeid shrimp at the
1974 National Marine Fisheries Service Galveston Laboratory. In Proceedings V
Congreso Nacional de Oceanografia, Guaymas, Mexico, 22-25 October 1974

Sparks, A.K. and C.T. Fontaine, Host response in the white shrimp, Penaeus setiferus, to
1973 infection by the larval trypanorhynchid cestode, Prochristianella penaei.
J.Invert.Pathol., 22(2):213-9

Zein-Eldin, Z.P. and J.L. Fenucci, Effect of protein levels and sources on growth of
1976 Penaeus astecus. Paper presented at the FAO Technical Conference on Aquaculture,
Kyoto, Japan, 26 May-2 June 1976

Zein-Eldin, Z.P. and S.P. Meyers, General consideration of problems in shrimp nutrition.
1973 Proc.Annu.Workshop World Maricult.Soc., 4:299-317